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ASSESSMENT OF SOME HEAVY METALS CONCENTRATION IN LETTUCE (*Lactuca sativa* [L.,]) CULTIVATED ALONG HIGHWAY IN ZARIA, NIGERIA

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ABSTRACT

Urban roadside soils are known to be the primary "recipients" of significant levels of heavy metals from a range of sources. Due to the possible negative ecological impacts of heavy metals, contamination of agricultural soil by these substances has become a serious environmental concern. The aim of this study was to determine the levels of certain heavy metals in lettuce grown alongside highway in Zaria, Nigeria. The soil and plant samples were collected at different distances from the roadside at two different locations namely: Marabar yakawada and Bomo farms (control). Atomic absorption spectrophotometer was used in the determination of the metal ions (Pb, Mn, Cd and Cr) concentration. The range of the concentration levels in *Lactuca sativa* in marabar yakawada and bomo were Pb (7.56 - 18.25mg/kg), Mn (2.06 - 6.46mg/kg), Cd (0.39 - 1.05mg/kg) and Cr (0.11 - 0.28mg/kg), and in soil were Pb (8.08 - 46.60mg/kg), Mn (3.97 - 11.30mg/kg), Cd (1.05 - 2.93mg/kg) and Cr (0.43 - 2.08mg/kg). Pb, Mn and Cd in lettuce were above the permissible limit set by FAO/WHO while Cr was below. The highest metal concentration suggests anthropogenic origins which confirm the effect of vehicular emissions on the roadside environment.

Keywords: Heavy metals; *Lactuca sativa*; Roadside; Soils; Zaria.

INTRODUCTION

Vegetable cultivation has a long history within and around urban areas. It ought to be discovered that the majority of these agricultural lands are contaminated with heavy metals, primarily as a result of anthropogenic activities such as industrial effluents, pesticides and fertilizers, and vehicle emissions (Dhakal and Kattel, 2019). Vegetables that have been contaminated have grown on these contaminated soils. Due to interference with plant metabolism, heavy metals in soil decrease crop output (Emile and Barde, 2020). According to Bhuiyan *et al*. (2021), heavy metals, such as lead and mercury are heavily contaminated in the soil, irrigation water, and some vegetables from peri - urban locations.

Any metallic element with a density of at least 4 g/cm^3, or five times or more that of water, and a recognizable toxic property is referred to as a "heavy metal" (Allen *et al*., 2020). These are the platinum group elements, as well as the following: lead (Pb), cadmium (Cd), zinc (Zn), mercury (Hg), arsenic (As), silver (Ag), chromium (Cr), copper (Cu), iron (Fe), and lead (Ag) (Ibrahim *et al*., 2018). Focusing on their contamination and effects on people and other living things, heavy metals are significant environmental pollutants that have attracted a lot of public and scientific interest in developed countries

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in recent years (Shi and Wang, 2021). Urban roadside soils are known to be the primary "recipients" of significant levels of heavy metals from a range of sources, including automobile emissions, coal burning waste, and other activities (Islamd *et al*., 2021). Due to the possible negative ecological impacts of heavy metals, contamination of agricultural soil by these substances has become a serious environmental concern.

The majority of tropical nations have vegetation with a variety of green vegetables, including spinach and lettuce, which are essential parts of the human diet. In Nigeria and other parts of West Africa, green leafy vegetables are used in soups from all different cultural backgrounds (Nagarajan *et al*., 2014; Mijinyawa *et al*., 2022). The edible portions of lettuce and radish were discovered to be more accountable than other vegetables for the accumulation of heavy metals in people (Gupta *et al*., 2019). In the majority of northern Nigeria's urban centers, lettuce consumption has greatly increased in popularity. There is a need to test and analyze these food items to make sure that the levels of these trace elements meet the established international requirements. This is due to the persistent nature and cumulative behavior of these heavy metals as well as the likelihood of potential toxicity effects from eating leafy vegetables. In this context, the levels of Pb, Cd, Cr, and Mn in lettuce (*Lactuca sativa* [L.]), one of the vegetables grown for commercial purposes in Zaria, were screened. The aim of this study was to determine the levels of certain heavy metals in lettuce (*Lactuca sativa* [L.]) grown alongside highway in Zaria, Nigeria.

MATERIALS AND METHODS

Study Area

This study was carried out along highway in Zaria. Zaria metropolis located at latitude 11°5'7.9476''N and longitude 7°43'11.8020''N. The major activity of the populace is farming. Two sampling locations were selected across the study and they include marabar yakawada and bomo (control).

Sample Collection and Preparation

Soil and plant materials of *Lactuca sativa* were collected from two different sampling locations along highway in Zaria. The samples were collected at 0, 10 and 20m away from the edge of the road. At each sampling point, three topsoil samples were collected at a depth of 0 - 5 cm and thoroughly mixed to form a composite sample, and transferred immediately into labeled polythene bags. Equally, whole plant of *Lactuca sativa* was carefully uprooted and labeled with a masking tape. Both samples were transported to the laboratory in the Department of Biology, A. B. U. Zaria. The leaves were removed from the stem. They were properly washed using tap water to remove the soil particles and debris then rinsed with distilled water. They were air dried for 72 hrs followed by oven dry for 24hrs at 105°c. The dried leaf samples were grinded using porcelain mortar and pestle, passed through a 2 mm sieve to obtain fine powder and stored at room temperature for analysis (Nuonom *et al.*, 2000).

Samples Digestion

Samples were digested at the Multi User Science Laboratory, Department of Chemistry, A. B. U. Zaria. The soil and plant samples were digested using the method of Ogunfowokan *et al.* (2009) and Erwin and Ivo (1992) respectively. About 0.5 g of the powdered plant sample was mixed with 20 mL of the acid mixture containing concentrated sulphuric acid, perchloric acid and concentrated nitric acid in ratio of 1:4:40

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by volume respectively. Thereafter the flasks were heated moderately at 70 °C for about 40 mins. Then the heat was increased to 120 °C. The mixture turned black for a while after which the solution became clear and white fumes appear signifying the end of digestion. After cooling, the sample solutions were then filtered through a whatman no. 1 filter paper into 50 ml volumetric flask and diluted up to the mark with distilled water for heavy metals analyses.

Determination of Heavy Metals Concentration in *Lactuca sativa* and Roadside Soils

Pb, Cd, Cr and Mn concentrations in the soil and *Lactuca sativa* samples were determined using Atomic Absorption Spectrophotometer (AAS) at the Multi User Science Laboratory, Department of Chemistry, A. B. U. Zaria (Okpanachi *et al*., 2016).

Determination of Vehicular Density

Visual counting of vehicles plying the entire sampling sites including the control site was done for 2 hours daily for a period of one week and the average vehicular density per hour was computed (Akpan and William, 2014).

Determination of Transfer Factor

The Transfer factor (TF) of the heavy metals from soils to the leaves of *Lactuca sativa* was computed in order to assess the extent of transfer of soil heavy metals into the plant. The transfer factor for the plant was calculated following the method of Lokeshwari and Chandrappa (2006) as follows:

$$TF = \frac{C\ leaves\ (mg/kg)}{C\ soil\ (mg/kg)}$$

Where C leaves and C soil represent the concentration of the metals in the leaves and soils respectively

Data Analysis

Data were subjected to analysis of variance (ANOVA) at 5% level of significance. Where significant differences were observed, Duncan’s Multiple Range Test (DMRT) was used to separate the means. Analysis was performed using SAS V. 9.2 (SAS, 2008).

RESULTS AND DISCUSION

Heavy Metals Concentration in Roadside Soils of the Study Area

The concentration of all the elements were observed to decrease with increase in distance from the road with the highest and lowest concentrations recorded at 0 and 20 m respectively in the two study areas (Table 1). However, with respect to locations, marabar yakawada showed higher concentration for all the heavy metals while bomo (control) was significantly lower (Table 2). The concentration of the elements in the roadside soil was in the order of: Pb > Mn > Cd > Cr.

The high level of elements recorded in soil could be from the automobile exhaust which is as a result of the presence of these elements in fuel and lubricating oils (Kaur *et al.,* 2021). They are released from vehicular emissions in the form of gaseous particulate matter into the atmosphere which eventually dissolves and fall as rain. This observation suggests that, roadside soils may be contaminated from anthropogenic activities such as vehicle exhaust and fuel combustion. However, sites with less concentration of metals may be attributed to the less vehicular density recorded in such locations.

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Table 1: Heavy Metals Concentration (mg/kg) of Soil across the Study Areas

Locations	Distance (m)	Pb	Mn	Cd	Cr
Marabar Yakawada	0	46.60±0.02^{a}	11.30±0.30^{a}	2.93±0.08^{a}	2.08±0.08^{a}
	10	38.08±0.07^{b}	7.51±0.40^{b}	2.51±0.00^{b}	1.75±0.03^{b}
	20	36.46±0.05^{c}	5.06±0.06^{c}	2.38±0.02^{c}	1.53±0.02^{c}
	Mean±SE	**40.38±1.99**	**7.96±1.16**	**2.60±0.11**	**1.79±0.10**
	p - Value	**0.000****	**0.001****	**0.007****	**0.009****
Bomo (Control)	0	15.47±0.47^{a}	6.53±0.02^{a}	1.23±0.02^{a}	0.90±0.09^{a}
	10	10.94±0.03^{b}	4.06±0.06^{b}	1.17±0.01^{a}	0.60±0.02$_{b}$
	20	8.08±0.08^{c}	3.97±0.01^{c}	1.05±0.05^{a}	0.43±0.02$_{c}$
	Mean±SE	**11.49±1.37**	**4.85±0.53**	**1.15±0.04**	**0.64±0.09**
	p - Value	**0.001****	**0.000****	**0.058^{ns}**	**0.016***

Means with different superscript letter(s) along the same columns were significantly different (p>0.05)

Key – * - Significant, ** - Highly Significant, ns – non significant

Pb – Lead, Mn – Manganese, Cd – Cadmium , Cr – Chromium, SE – Standard Error

Heavy Metals Concentration in the Leaves of *Lettuce sativa*

In the leaves of *Lactuca sativa,* the concentration of elements were generally observed to decrease with increase in distance from the roadside as the highest and lowest concentration of all the heavy metals were observed at 0 and 20m from the roadside in the two study areas. The concentration of heavy metals in *Lactuca sativa*, leaves were in the order of: Pb > Mn > Cd > Cr. Marabar yakawada showed higher concentration for all the heavy metals while bomo (control) was significantly lower (Table 2).

The these heavy metals analyzed in the leaves of the lettuce based on distance from roadside showed that, Pb, Mn, Cd and Cr level decreased significantly with increasing distance from the road. This is an indication that, the distribution of these metals in the environment is strongly but inversely correlated with the increase in the distance from road (Werkenthin *et al.,* 2014). The range of Lead level for *Lactuca sativa* was found to be highest in the leaves and these concentrations were in the order of Marabar Yakawada > Bomo (control). From the distribution of this element with respect to location, it was observed that there is a strong and direct relationship between the concentrations of Pb and vehicular densities. This high Pb level may be attributed to vehicular emissions since there was no other visible source of pollution in the study area and this conforms to the report of Upahi *et al*. (2021) who reported that Pb pollution in roadside environmental samples comes from combustion of gasoline that contains tetraethyl lead as anti-knock agent. The installation of catalytic converter in some vehicles is another source of Pb into the environment due to abrasion within the vehicular components (Upahi *et al*., 2021). Comparing these values with others, it was observed to be lower than the mean values reported by Oloruntola *et al.* (2021) who recorded 30 - 40 mg/kg in leaves of *Saba florida* in Nigeria. However, the values were higher than that observed in a study by Abbey *et al.* (2021) who recorded 0.043 mg/kg and 0.007 mg/kg of Pb in the root and leaf of *Lactuca sativa* respectively. Similarly, Mn, Cd and Cr decreases with increasing distance from the road sites which could be associated with different vehicular emission. Pb, Mn and Cd concentrations were above the permissible limits as recommended by WHO/FAO (2001), while Cr was below this indicates that lettuce when consumed could be associated with Pb, Mn and Cd toxicity.

Table 2: Heavy Metals Concentration (mg/kg) in Lettuce across the Study Areas

Locations	Distance (m)	Pb	Mn	Cd	Cr
Marabar Yakawada	0	18.25±0.25[a]	6.46±0.04[a]	1.05±0.07[a]	0.28±0.03[a]
	10	13.13±0.03[b]	4.06±0.06[b]	0.87±0.02[b]	0.30±0.01[a]
	20	11.43±0.08[c]	3.59±0.02[c]	0.71±0.01[c]	0.23±0.02[a]
	Mean±SE	**14.27**±1.30	**4.70±0.56**	**0.87±0.06**	**0.27±0.02**
	***p* - Value**	**0.000****	**0.000****	**0.019***	**0.219[ns]**
Bomo	0	9.18±0.08[a]	3.11±0.00[a]	0.52±0.01[a]	0.17±0.02[a]
	10	8.11±0.00[b]	2.54±0.03[b]	0.43±0.01[b]	0.13±0.01[b]
	20	7.56±0.04[c]	2.06±0.05[c]	0.39±0.01[c]	0.11±0.01[c]
	Mean±SE	**8.28±0.30**	**2.57±0.19**	**0.45±0.02**	**0.13±0.01**
	***p* - Value**	**0.000****	**0.001****	**0.006***	**0.046***
	FAO/WHO	**0.30**	**0.20**	**0.20**	**1.30**

Means with different superscript letter(s) along the same columns were significantly different ($p>0.05$)

Key – * - Significant, ** - Highly Significant, ns – non significant

Pb – Lead, Mn – Manganese, Cd – Cadmium , Cr – Chromium, SE – Standard Error

FAO/WHO (2001) Permissible Values in Plants (mg/kg)

Vehicular Density

In general, the average vehicular density of 807 per hour was observed at marabar yakawada while bomo (Control) had 38 vehicular density per hour (Table 3). Marabar yakawada with the higher vehicular density revealed high amount of heavy metals while sites with less vehicular density recorded (bomo) revealed less concentration of metals. Therefore, heavy metals concentration might be attributed to vehicular density.

Table 3: Vehicular Density and GPRS across Sampled Locations in the Study Areas

Locations	Vehicular Density/Hr.	Latitude	Longitude
Marabar Yakawada	807	11°16'6.0"N	7°24'0.0"E

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Bomo (Control)	38	11°10'55.3"N	7°37'47.2"E

Transfer factor of soil heavy metals into the Leaves of *Lactuca sativa*

Table 4 shows the transfer factor of soil heavy metals into the leaves of *Lactuca sativa*. Generally, among the elements, lead and chromium showed the highest and lowest transfer factor of 0.94 and 0.13 in *Lactuca sativa* respectively. Transfer factor (TF) >1 indicates heavy metal accumulators.

Generally, the result showed that, transfer factor (TF) values were in the order of Pb > Mn > Cd> Cr. This observation shows that, among all the metals studied, lead is easiest to be transferred. This observation is in line with the findings of Fonmboh *et al*. (2020) who reported that, Pb had the highest transfer factor value than all other heavy metals in his study and also more easily available for plant uptake. Also, *Lactuca sativa* recorded TF >1 values (approximately) in Pb and Mn, which is an indication that, the plant had the potential of accumulating metals from the roadside soil which may eventually be transferred into the food chain through the consumption of roadside plants (Salau *et* al., 2023; Ibrahim *et al*., 2018; Mijinyawa *et al*., 2022).

Table 4: Transfer Factor of Soil Heavy Metals into the Leaves of *Lactuca sativa*

Locations	Distance (m)	Pb	Mn	Cd	Cr
Marabar Yakawada	0	0.39	0.57	0.36	0.13
	10	0.34	0.80	0.35	0.17
	20	0.31	0.71	0.30	0.15
Bomo (Control)	0	0.59	0.48	0.42	0.19
	10	0.74	0.63	0.37	0.22
	20	0.94	0.52	0.37	0.26

NOTE - Plant with TF>1 denotes Metal Accumulator
Pb – Lead, Mn – Manganese, Cd – Cadmium , Cr – Chromium

CONCLUSION

The concentration of all the heavy metals assessed across marabar yakawada was found to be significantly higher than the control (bomo). Also, the heavy metals concentration in soils and leaves of *Lactuca sativa* decreased with increasing distance from the roadside, with the highest and lowest concentration observed at 0m and 20m respectively, and with marked significant difference between each distance. Therefore, distance from the roadside and vehicular densities of the sampled locations had a significant effect on the heavy metals concentration in the leaves of *Lactuca sativa*. These suggest anthropogenic origins which confirm the effect of vehicular emissions on the roadside environment. In view of these findings, there is need for regular monitoring of heavy metal concentration in both soil and *Lactuca sativa* because of the possibility of being transferred to man through food chain, it is also recommended that, the plant should be subjected for further research and assessment on their phytoremediation abilities.

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